THREE-DIMENSIONAL MISCIBLE DISPLACEMENT SIMULATIONS IN POROUS MEDIA WITH GRAVITY OVERRIDE

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High accuracy, three-dimensional numerical simulations of miscible displacements with gravity override in homogeneous porous media are carried out for the quarter five-spot configuration. Special emphasis is placed on describing the influence of viscous and gravitational effects on the overall displacement dynamics in terms of the vorticity variable. Even for neutrally buoyant displacements, three-dimensional effects are seen to change the character of the flow significantly, in contrast to earlier findings for rectilinear displacements. At least in part this can be attributed to the time dependence of the most dangerous vertical instability mode. Density differences influence the flow primarily by establishing a narrow gravity layer, in which the effective Peclet number is enhanced due to the higher flow rate. However, buoyancy forces of a certain magnitude can lead to a pinch-off of the gravity layer, thereby slowing it down. Thus, optimal displacement efficiencies at intermediate values of the gravity parameter can be the result of a delicate balance between the viscosity and gravity related vorticity contributions. The viscous vorticity has to form sufficiently large fingers below the gravity layer, before gravitational vorticity can lead to their beneficial interaction with the gravity layer itself. Overall, an increase of the gravitational parameter is found to enhance mostly the vertical perturbations, while larger *Pe* values act towards amplifying azimuthal disturbances. With respect to integral measures characterizing the displacement process, the asymptotic rate of growth of the mixing length is seen not to depend on the gravity parameter. On the other hand, it varies with the viscosity ratio, and it becomes independent of the Peclet number only for very large values of this parameter. The total interfacial area is seen to grow with an asymptotic exponent of about 0.6 for all parameter combinations, except for very low Peclet numbers.